RADIOACTIVITY AS A BASIS FOR CORRELATION OF GLACIAL DEPOSITS IN OHIO[1]

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Robert Moxham, staff geologist of the Geophysics Branch, U. S. Geological Survey, recently informed the writer that glacial deposits of Wisconsin and Illinoian ages in Ohio were noticeably different in their radioactivities as indicated by a scintillation counter. This observation led to an investigation of glacial deposits in northeastern and east-central Ohio to determine whether radioactivity can furnish a basis for correlating glacial deposits of various ages.

Deposits of the Grand River Lobe were investigated in Trumbull, Columbiana, Geauga, Portage, Lake, and Cuyahoga Counties in northeastern Ohio. Deposits of the Scioto Lobe were investigated in Licking County in east-central Ohio. The deposits in northeastern Ohio were mapped and dated by White (1951a, p. 967–977; 1951b, p. 1489; 1953, p. 37); the deposits in Licking County were mapped and dated by Mr. George D. Dove of the U.S. Geological Survey (manuscript in preparation). Messrs. White and Dove mapped the glacial deposits in their respective areas as part of the Statewide program of ground-water investigations being made by the U.S. Geological Survey in co-operation with the Division of Water, Ohio Department of Natural Resources. The cooperation and field assistance of Dr. White and Mr. Dove are gratefully acknowledged.

EQUIPMENT AND FIELD METHODS

Two instruments were used to determine the radioactivity of the glacial deposits; a scintillation counter and a Geiger-Müller counter. The scintillation counter measures gamma radiation by means of a dense sodium iodide crystal which intercepts practically every gamma ray passing into it. The crystal is coupled to a photomultiplier tube that transmits the impulses to a meter which indicates the radiation intensity in milliroentgens per hour. The reading is not quantitative unless the instrument is calibrated. In this investigation the scintillation counter was not calibrated and the readings are merely relative measures of radiation intensity. The Geiger-Müller counter employs a gas-filled tube which reacts to about 1 percent of the gamma rays that penetrate it. The Geiger-Müller counter used in this investigation has two devices for indicating radioactivity: one is a meter that indicates intensity in milliroentgens per hour, useful only for sources radiating strongly enough to give a steady reading; the other is a scaler computer that counts the number of pulses in the Geiger-Müller tube. The number of counts per minute can then be used to obtain a near measure of true radioactivity with a calibration chart made for this particular instrument. This calibration chart is a curve obtained by plotting known radioactive intensities against counts per minute registered by the instrument when exposed to various samples of known intensities. The Geiger-Müller counter is sensitive to gamma and beta rays, the scintillation counter only to gamma rays. However, beta rays have low penetrating power and probably contributed little to the readings from the glacial deposits. The scintillation counter records many times more gamma rays from the same source as the Geiger-Müller counter, and, because it averages many more pulses per minute, gives a steadier reading. Both instruments normally indicate a small intensity (background) due to cosmic rays and internal contamination.

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An important factor in radiation studies is mass effect, which means simply that the mass of the sample has an influence on its radiation intensity. Thus, a radioactive deposit in place will give a higher reading than a hand sample of the same material. Grain size also has an effect on radiation, and specimens ground to pea-gravel size and to powder will give successively higher readings than a specimen of the same volume left whole. In this investigation it was found that a typical exposure of till might give several different readings depending on the presence of gravelly or sandy layers. In an effort to obtain an average measure of radioactivity several readings were made at different places in such material.

The procedure found to be most satisfactory was to auger holes into the material to be tested, the holes being either of the size of the Geiger-Müller probe, about an inch in diameter and a foot deep, or that of the scintillation-counter barrel, about 3 inches in diameter and 6 inches deep. Placing the probes in the holes shielded them from most stray radiation, so that the instruments gave truer readings. At most of the test sites, the hole made for the scintillation counter was used for the Geiger-Müller probe also, to permit the tests to be made more rapidly. In northeastern Ohio, the probes were placed in the exposed material at various points where changes in composition were observed. In Licking County the readings were made at the contact of the A and B horizons in the soil, at the contact of the B and C horizons, and as low as possible in the C horizon, usually about 6 feet below the top of the exposure. Readings in till were not significantly different between soil zones, except where the different zones coincided with changes in composition. Leaching showed no apparent effect on radiation, nor did oxidation.

RESULTS AND DISCUSSION

Summarized in table 1 are the results of the tests in terms of ranges and median values of the observed readings. As shown in the table, there is, with one exception, a general trend from higher readings in younger deposits to lower readings in the older deposits. The trend is more pronounced in northeastern Ohio than in Licking County. In the Licking County readings little difference is shown between the various Wisconsin substages. The ranges of the readings from deposits in Licking County also are smaller than the ranges of the readings from deposits of corresponding ages in northeastern Ohio, perhaps because fewer tests were made in Licking County. The Licking County readings are, however, comparable in intensity to those made in northeastern Ohio.

Although most of the Geiger-Müller readings are in agreement with the scintillation-counter readings, the instruments do not always substantiate each other, especially in readings from coarse material. Poor correlation between readings may result from differences in grain size, which may account also for the wide ranges of the readings from deposits of the same age. Contrary to the general trend is the median Geiger-Müller reading from Illinoian deposits in northeastern Ohio, which is as high as the median of late Wisconsin deposits.

CONCLUSIONS

The principal advantage, thus far, of determining radioactivities of glacial deposits seems to be as an aid in making general distinction between deposits of pre-Illinoian(?) and Illinoian ages, and between deposits of Illinoian and Wisconsin age. General field use of the method for simple and accurate determinations of the age of glacial deposits does not appear imminent. A major disadvantage of the method is that the instruments are delicate and must be handled carefully. Moreover, they are very expensive. It is unfortunate that one instrument used in this investigation was not calibrated, for this will prevent comparison of the readings with future readings of other instruments. Obviously, more use must be made of the method before its true value is known. A laboratory investigation

TABLE 1

READINGS FROM GLACIAL DEPOSITS OF VARIOUS AGES IN OHIO

Age		Description	Range & median[1] of readings (line shows approx. trend) Geiger counter (cpm)[5]	Scintillator (mr/h)[5]
NORTHEASTERN OHIO				
Latest Cary[2]	4[3]	Silty pebbly till, some sand		
Late Cary[4]	16	Compact clay till, silty		
Early Cary	13	Sandy till with gravel		
Tazewell	14	Coarse stony, till, sandy		
Illinoian	6	Clayey till; gravel fresh & weathered		
Pre-Illinoian (?)	4	Colluviated, weathered outwash ?		
			40 60 80	.020 .030 .040
EAST-CENTRAL OHIO				
Late Wisconsin (Middle Cary?)	7	Clayey, fine shaley particles, sandy		
Middle Wisconsin (Early Cary?)	7	Shaley till, sandy		
Early Wisconsin (Tazewell)	3	Sandy till, coarser than late Wisconsin		
Illinoian	7	Sandy, oxidized till, coarser than Wisconsin		
			40 60 80	.020 .030 .040

1/ ____ median of all readings from a particular age.

2/ Painesville member, Lake Escarpment moraines.

3/ Number of sites sampled.

4/ Defiance moraine and related till.

5/ (cpm) counts per minute; (mr/h) milliroentgens per hour.

of samples of known ages in various quantities and grain sizes might result in a more reliable field technique. A radioactivity investigation in which a large number of tests were made possibly could serve as a basis for correlation of gamma-ray logs of wells and point the way to an important new technique of subsurface mapping.

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